

Effect of mains voltage on the actual heater power

Heater power depends on voltage

The power stated for a heater applies at its rated voltage. If a heater is rated 5.5 kW at 230 V, its actual power increases at a higher voltage. For a resistive heater, the relationship can be approximated by $P = U^2 / R$. This means that an increase in voltage causes a more-than-proportional increase in power.

Example: 5.5 kW / 230 V heater

Such a heater has a resistance of approximately 9.62 Ω and draws about 23.9 A at 230 V. If the mains voltage rises to 250 V, the same heater draws about 26.0 A and its power rises to approximately 6.50 kW. This is about 18% more than its rated power.

Voltage	Actual power	Current	Power increase
230 V	5.50 kW	23.9 A	0.0%
240 V	5.99 kW	25.0 A	8.9%
250 V	6.50 kW	26.0 A	18.1%
253 V	6.65 kW	26.3 A	21.0%

Why does this matter for the controller?

If the controller maximum permitted load is specified as 5.5 kW at 230 V, connecting a 5.5 kW heater leaves practically no margin. When voltage rises, both heater power and current increase. As a result, the actual load on the controller power stage may exceed the permitted value.

Photovoltaics and high mains voltage

In installations with photovoltaics, mains voltage may periodically be higher, especially when generation is high and local consumption is low. If the socket voltage is around 250 V, a 5.5 kW / 230 V heater no longer operates at 5.5 kW but at about 6.5 kW. This must be considered when selecting a heater for the controller.

How to select the load safely

Do not select a heater exactly at the controller maximum power limit if elevated mains voltage occurs in the installation. Leave a suitable power and current margin. Check the actual mains voltage at the place of use and, for larger loads, also the actual current. If the controller allows maximum power to be limited, this function can be used according to the model instructions, but it does not replace correct selection of heater, cables, connectors and protective devices.

Most important

A 5.5 kW rating on the heater does not mean 5.5 kW at every voltage. For a typical resistive heater, increasing voltage from 230 V to 250 V raises power from 5.5 kW to about 6.5 kW. If the controller is rated for a maximum 5.5 kW load, this situation may exceed its permitted current or load power.